

# ***Interactive comment on “Inter-annual tropical Pacific climate variability in an isotope-enabled CGCM: implications for interpreting coral stable oxygen isotope records of ENSO” by T. Russon et al.***

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This manuscript provides a rigorous and comprehensive analysis of the various approaches to, and assumptions and uncertainties associated with, interpreting  $\delta^{18}\text{O}$  variability in modern and fossil corals as a function of sea surface temperature and/or  $\delta^{18}\text{O}_{\text{sw}}$  (or by extension sea surface salinity). In the absence of a sufficient observational record investigate these assumptions, the authors utilize an isotope enabled control simulation of the HadCM3 model to assess these approaches. Although their results are model dependent and subject to the model biases, the authors did a good

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job in qualifying their results in context of the known model biases and uncertainties (with a few exceptions, see below). The manuscript is also well written, although the clarity could be improved with some minor reorganization and revisions (see technical comments below). The manuscript is within the scope of the journal, *Climate of the Past* Discussions, and presents a substantial contribution to the coral paleoclimate community.

General comments: Pseudo-coral modeling work would benefit from an investigation of the stationarity of the  $\delta^{18}\text{O}_{\text{sw}}$  –SSS relationship in this model, as this approach also requires the assumption that this relationship does not vary significantly through time. The manuscript would be strengthened by an investigation of the multi-decadal to centennial stationarity of this relationship, as the authors have done for the  $\delta^{18}\text{O}_{\text{coral}}$ –SST relationship.

Minor comments and technical corrections/suggestions:

Page 742, Line 6: I suggest replacing “affirms” with “suggests”

Page 742 Line 21- Page 743, Line 2: consider adding earlier references for temperature dependent fractionation, such as:

(1) Epstein, S., et al. (1953), Revised carbonate-water isotopic temperature scale, *Geol. Soc. Am. Bull.*, 64(11), 1315–1326, doi:10.1130/0016-7606(1953)64[1315:RCITS]2.0.CO;2. (2) Grossman, E. L., and T.-L. Ku, Oxygen and carbon isotopic fractionation in biogenic aragonite: Temperature effects, *Chem. Geol.*, 59, 59-74, 1986. (3) O’Neil, J. R., R. N. Clayton, and T. K. Mayeda, Oxygen isotope fractionation in divalent metal carbonates, *J. Chem. Phys.*, 51(12), 5547-5558, doi: 10.1063/1.167982, 1969.

Or add “e.g.,” in front of references to indicate that this is an abbreviated list of (recent) references.

Page 743, line 12: Why restrict this statement to fossil corals? I suggest that you add

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modern corals here: "...provides a strong basis for the use of modern (living) and fossil  $\delta^{18}\text{O}$  coral variability as a tool to..."

Page 743, line 19: remove extra "from"

Page 743, line 23-24: I suggest the authors break up this long sentence: "...the  $\delta^{18}\text{O}$  contribution may dominate the SST signal.  $\delta^{18}\text{O}$  coral records from these locations..."

Page 743, line 26: list the "hydrological cycle influences" that must be considered in these studies

Page 744, line 1: I suggest changing to "Due to the dual climatic controls on  $\delta^{18}\text{O}$  coral arising from SST and  $\delta^{18}\text{O}$ sw, quantifying the..." and breaking the sentence up after "important proxy records." "This uncertainty provides the motivation..."

Page 744, line 8- Page 745, line 19: I suggest the authors break this paragraph up into more digestible parts, by first listing all of the approaches that can be used in a numbered list, and then discussing the strengths and weaknesses of each approach in the following paragraph (referring to each approach by number from the previous paragraph). Then start a third paragraph at "The principle motivation for the present study..."

Page 744, line 16: change to "time scales"

Page 744, line 20: change to "time domain"

Page 744, line 28: I suggest striking "indeed"

Page 745, line 11: change equal sign to a hyphen

Page 745, line 14: change "alones" to "alone"

Page 746, line 2: I suggest adding SSS here: "in the absence of temporal instrumental records of  $\delta^{18}\text{O}$ sw and SSS"

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Page 746, line 3-4: I suggest changing to “the assumption has been made that the modern spatial slope between paired observations of these variables (LeGrande and Schmidt 2006) may usefully represent the temporal slopes”

Page 746, line 7: change “between” to “of”

Page 746, line 19: refer specifically to the assumptions you are referring to here from above

Page 746, line 23: strike “expected”

Page 746, line 25: change “it is thought that” to “recent work suggests that” (there is still substantial work supporting forced changes as well)

Page 747, line 19: I suggest moving page 748 lines 3-26 “Water isotope processes...considered invariant.” to the discussion of experimental design (Pg 747, line 19) and start new paragraph at “Figure 1 illustrates...”

Page 747, line 20: change to: “of the model fields for SST (Fig. 1 a,b), SSS (Fig. 1 c,d), precipitation (Fig. 1 e,f),  $\delta^{18}\text{O}_{\text{sw}}$  (Fig. 1 g,h), and  $\delta^{18}\text{O}_{\text{coral}}$  (Fig. 1 i,j).”

Page 747, line 25: either strike “as presented here” (vague) or refer specifically to where this can be found in the text and/or figures.

Page 748, line 18: add “of” after  $\sim 200\%$

Page 749, line 24: I suggest changing “affirms” to “supports”

Page 750, line 21: add “in eq. (1)” after “ $\delta^{18}\text{O}_{\text{sw}}$ ”

Page 751, line 10: I suggest changing “as well as” to “or in”

Page 752, line 4-5: I suggest changing to: “if only the SST-driven precipitation anomaly effect was important”

Page 752, lines 16-18: yes, there is really only one exception in the southwest Pacific, where a tongue of negative  $F_{\text{cov}}$  is present. This looks like it may be an artifact and

worth addressing/discussing.

Page 754, line 4: Looking at figure 2, I think this should say that model  $\text{var}(\delta^{18}\text{O}_{\text{coral}})$  increases, rather than decreases, as you move westward.

Page 754, line 17: give value of the imposed slope here to remind readers: “from that of the imposed proxy relationship slope of  $-0.23\% \text{ K}^{-1}$ ”

Page 754, line 20: I suggest a new paragraph at “In contrast. . .”

Page 755, line 7: change “substantially” to “substantial”

Page 755, lines 5-10: This is a very interesting and important result, and worth discussing further in the context of reported  $\delta^{18}\text{O}_{\text{coral}}$ -SST relationships. Could this explain some of the spatial variability in reported  $\delta^{18}\text{O}_{\text{coral}}$ -SST relationships (e.g., Evans et al. 2000)?

Page 756, line 19: define net precipitation isotope anomaly, which I gather from the caption of figure 5 is the product of the precipitation anomalies and the  $\delta^{18}\text{O}_{\text{precip}}$

Page 756, lines 22-24: what about during central Pacific El Niño events?

Page 759, line 16: change “sufficiently” to “insufficiently”

Page 760, line 14: change “are” to “all”

Page 761, lines 15-17: I suggest you change to: “will overestimate the relative contribution from  $\delta^{18}\text{O}_{\text{sw}}$  to  $\text{var}(\delta^{18}\text{O}_{\text{pseudo-coral}})$  compared to pseudo-corals modeled from the HadCM3 temporal SSS-  $\delta^{18}\text{O}_{\text{sw}}$  slopes.”

Page 761, lines 15-29: this is, of course, assuming the HadCM3 model temporal slopes reflect the true values, which may or may not be the case. So “true value” throughout this discussion should be replaced with something like “value observed in the HadCM3 model” or “HadCM3 modeled value.” For comparison, the control simulation of the isotope-enabled GISS ModelE-R displays an even larger spatial SSS-  $\delta^{18}\text{O}_{\text{sw}}$  slope of

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0.35 ‰PSU (Thompson, D.M., T.R. Ault, M.N. Evans, J.E. Cole, J. Emile-Geay, and A. LeGrande, “Coral- CGCM comparison highlights role of salinity in long-term trends.” P. Braconnot, C. Brierley, S.P. Harrison, L. von Gunten (eds) El Niño Southern Oscillation: observation and modeling, PAGES news 21(2) 2013, in press).

Page 762, line 3: replace period after climate with a comma

Page 763, line 2: add comma before although

Figure 1 caption, I suggest changing line 3 to: “The entire simulation was used as the reference period for the removal of the annual climatology prior to the variance calculations”

Figure 4 caption: change to “. . ., and (B) the RSME10. . .” as you are still referring to the spatial distribution of this field from line 1.

Figure 5 caption: I suggest moving “in the Western Cold Tongue box (the location of which is shown on Figs. 2, 4)” to the end of the sentence. Line 5: fix “isotoppe”

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Interactive comment on Clim. Past Discuss., 9, 741, 2013.

CPD

9, C338–C343, 2013

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